BIOLOGICAL SURVEYS
OF
FIVE TROUT FARMING OPERATIONS
IN
SOUTHERN ONTARIO

December, 1982

Ontario
Ministry
of the
Environment

BIOLOGICAL SURVEYS OF FIVE TROUT FARMING OPERATIONS IN SOUTHERN ONTARIO

Water Resources Assessment Unit
Technical Support Section
Southwestern Region
and
West Central Region

Ministry of the Environment

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SUMMARY

Impairment of water quality, as reflected by benthic flora and fauna, was documented immediately downstream from trout farming operations. The severity of impairment appeared related particularly to the available dilution offered by the receiving stream, but also to the degree of waste treatment afforded.

The most severe impact was documented downstream from the Spring Valley Trout Farm, where no waste treatment was provided. The total number of organisms increased from 288 upstream to 3680 downstream, owing primarily to large numbers of Chironomidae (midge) and Simuliidae (black flies). In addition, the normally clean, gravelly substrate was heavily covered with organic deposits and supported luxuriant growths of water cress and Cladophora. A similar case of water quality impairment was documented downstream from the Springhills Trout Farm where waste water passes through a small settling basin which provides minimal retention time.

Normal effluents from both of these operations constitute the majority of flow in the immediate receiving water course. Therefore, both the lack of water for dilution and the minimal treatment contributed to the impairment observed downstream (accumulation of solids, luxuriant plant growth and the increase in numbers of organisms).

Less impairment was observed downstream from the three remaining operations, all of which had some degree of treatment (i.e. large settling ponds, sand filters or settling tanks). Also, each of these operations discharged their wastes to a flowing stream where dilution was available. However, in the immediate vicinity of the discharge there were still areas of solids accumulation

(organic material), disruption of the animal benthos and increased plant growth.

RECOMMENDATIONS

Additional studies need to be conducted to determine the treatment requirements for trout farming wastes sufficient to afford protection for the sensitive cold water environment in which trout farms are located.

Minimum treatment requirements should include the removal of any suspended wastes, both from flow-through water and those produced during cleaning operations. These wastes smother the stream bottom, introduce unwanted nutrients and produce excessive quantities of food that distort the aquatic community. Treatment must also consider a means of removing phosphorus.

INTRODUCTION

Earlier surveys and general field observations by both the Southwestern and West Central Regions have indicated enrichment downstream from trout farming operations. The majority of these operations are located, through necessity, along cleaner, cooler streams. Considerable effort is presently being directed to the protection of our high water quality streams through control programs aimed at agricultural practices and industrial and municipal wastewater treatment.

The results of surveys documenting the water quality impairment downstream from trout farms will hopefully provide impetus for improved treatment facilities.

Such a need could then be implemented through the joint efforts of the Ministry of Natural Resources and the Ministry of the Environment.

This survey was conducted by staff of the Technical Support Sections of the West Central and the Southwestern Regions of the Ministry of the Environment . Five operations were studied in all, two located within the West Central Region and three within the Southwestern Region (Figure 1). The five hatcheries studied are listed below:

1. Spring Valley Trout Farm
   Wilmot Township, Waterloo County

2. Aberfoyle Fisheries
   Puslinch Township, Wellington County

3. Blue Springs Trout Farm
   Bentinck Township, Grey County

4. Springhills Trout Farm
   Holland Township, Grey County

5. Aquafarm Canada Limited
   Osprey Township, Grey County

METHODS

During the summer of 1981, biological surveys were conducted in the vicinity of the trout farming operations to assess the degree of impact that wastewater effluents were having on receiving watercourses. Comparisons were made between the benthic fauna collected upstream as opposed to fauna collected downstream. Persistent environmental

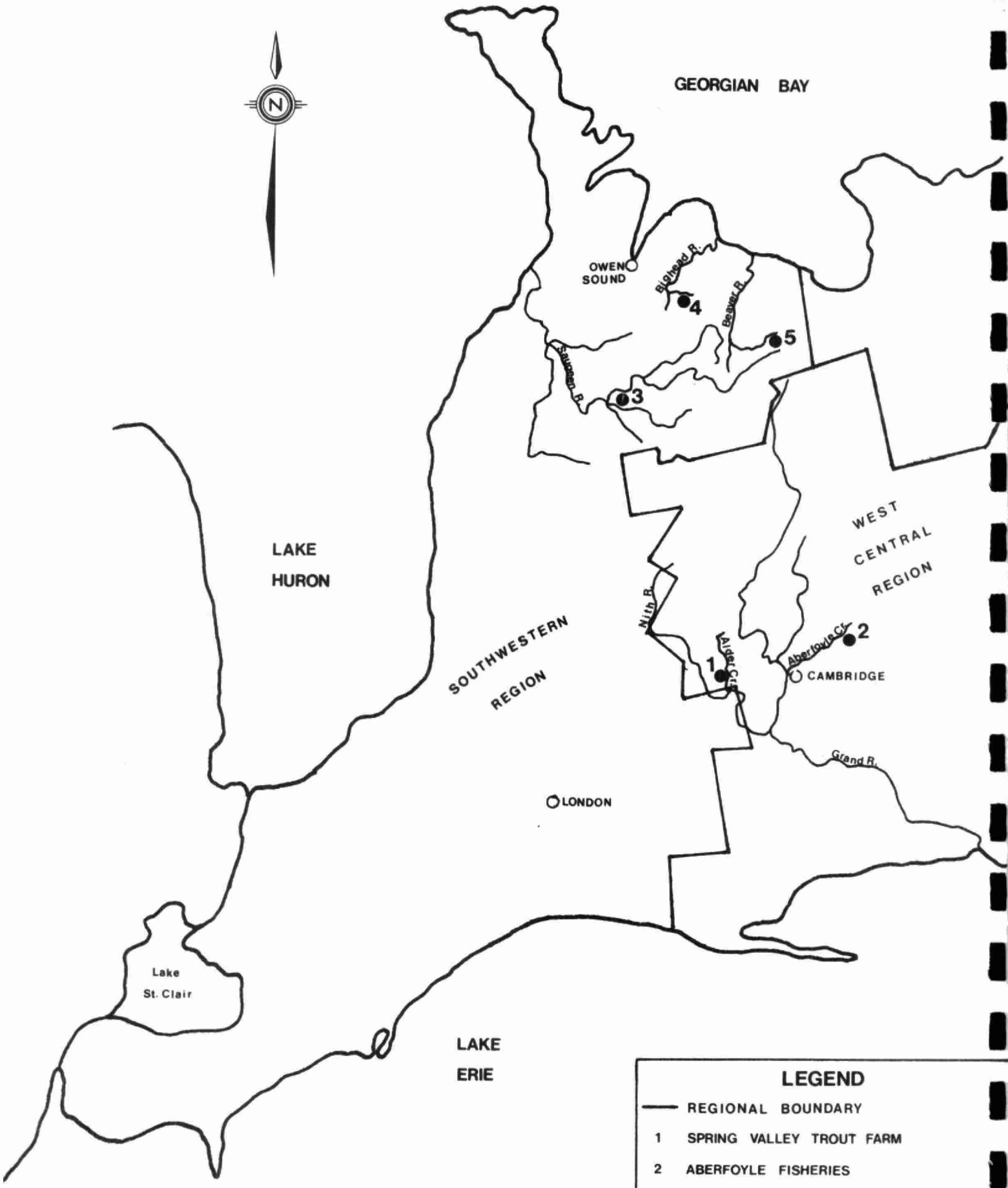

Figure 1: Location map

changes affect the distribution and abundance of particular species and hence the composition of the communities (Warren, 1971). Therefore, any changes in water quality which may have occurred due to trout farming operations should be reflected by the benthic fauna.

Benthic macroinvertebrate samples were collected upstream and downstream of the five operations using a Surber sampler. Samples were taken at riffle areas with the number of samples dependant on the stream width. In addition to quantitative sampling, qualitative samples were collected at each site over a ten-minute time period using a hand sieve and bucket.

Samples were cleaned, and sorted in the field and preserved in 70% ethanol for later identification.

Water samples were collected at each station and returned to the London laboratory for the analysis of Kjeldahl nitrogen, free ammonia, nitrite nitrogen, nitrate nitrogen, total and soluble phosphorus.

Additionaly, notes were kept on the types and abundance of aquatic plants, substrate type and the degree of siltation observed at each sampling area.

RESULTS AND DISCUSSION

BIOLOGICAL ANALYSIS

For simplicity, results will be presented on a case-by-case basis. Site specific data pertaining to substrate types, stream width and aquatic plant growth for each of the sampling stations are summarized in Table 1.

Table 1. Site specific data for sampling locations.

1. Spring Valley Trout Farm

upstream
- width 1.3 meters
- sand, gravel, cobble
- calcium buildup on rocks
- limited water cress growth

downstream
- width 1.6 meters
- gravel, cobble
- heavily silted
- 20% Cladophora growth
- heavy water cress growth

2. Aberfoyles Fisheries

upstream
- width 1.3 meters
- gravel, cobble
- clean bottom
- limited Cladophora and moss growth

downstream
- width 3 meters
- gravel, cobble
- some silting
- limited water cress growth
- odd patch of Cladophora growth

3. Blue Springs Trout Farm

upstream
- width 11 meters
- gravel, cobble
- clean bottom
- limited algal growth

downstream
- width 10 meters
- gravel, cobble
- clean bottom
- 20% Cladophora and moss growth

4. Springhills Trout Farm

upstream
- width 2 meters
- gravel, cobble
- some silting
- limited Cladophora and moss growth

downstream
- width 2 meters
- gravel, cobble
- some silting
- limited Cladophora and moss growth

5. Aquafarm Canada Limited

upstream
- width 8 meters
- sand, gravel, cobble
- calcium buildup on rocks
- limited algal growth
- some pondweed species

downstream
- width 8 meters
- gravel, cobble
- calcium buildup on rocks
- 70% water cress growth
- limited Cladophora and moss growth

1. Spring Valley Trout Farm

Station locations and the basic operational layout of the Spring Valley Trout Farm are illustrated in Figure 2. The farm obtains the majority of its water supply from a tributary of Alder Creek via a large collecting pond while the remainder is supplied by several springs and wells. The collecting pond is stocked with trout and supports a fishery on a put-and-take basis. From here, the water passes through a number of raceways which are operated in series. The operation has no treatment facilities (i.e. settling ponds). Larger waste particles that do settle out in the raceways are periodically cleaned out and deposited on the surrounding land as fertilizer. Wastewater (approximately 3700 liters per minute) from the operation is discharged to a ditch which forms a headwater tributary of Alder Creek.

The upstream sampling area was characterized by a clean gravelly substrate with some calcium build-up present. This build-up is commonly found in areas fed by hard spring waters. Aquatic plant growth was observed as being sparse and consisting only of water cress. In contrast, the downstream sampling site was grossly affected by the trout farm effluent. The normally gravel substrate was heavily covered with organic material (excess fish food and fish excrement) especially in the area between the discharge and the sampling point where in some spots the depth of organic material was in excess of 25 cm. This area was also observed to have luxuriant growths of water cress and approximately 20% coverage of Cladophora growth. Waste deposits and enrichment (plant growth) were observed to continue downstream to the point where the creek joined another branch of Alder Creek (150 meters) and flow (dilution) was increased.

Macroinvertebrate sampling results are summarized in Table 2. Comparing upstream and downstream results, a decrease in total taxa was observed downstream which was attributable to a decline in representation of pollution intolerant species such as alderflies, stoneflies, mayflies

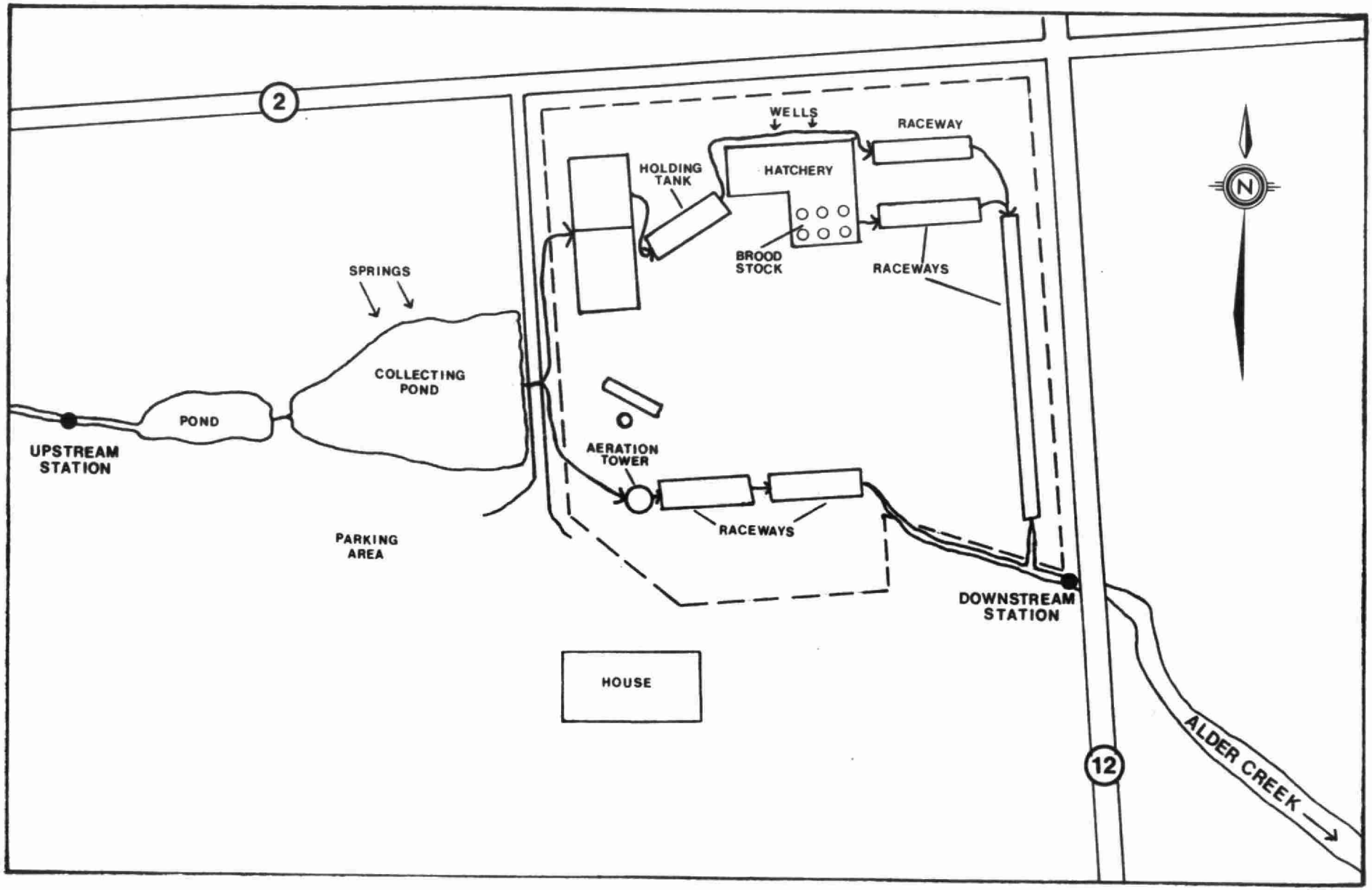

Figure 2: Station locations and operational layout for the Spring Valley Trout Farm

Table 2. Macroinvertebrates collected from Alder Creek in the immediate vicinity of the Spring Valley Trout Farm, August 10, 1981.

Organism	Upstream		Downstream	
	Surber	Qual.	Surber	Qual.
Megaloptera				
Sialis (alderflies)	2			
Plecoptera (stoneflies)				
Atoperla	5	P	1	
Isocapnia	69	P		
Nemoura	17			
Ephemeroptera (mayflies)				
Baetis	59	P	1	
Trichoptera (caddis flies)				
Dolphilodes	20	P		
Frenesia		P		
Hydropsyche	1		1	
Lepidostoma	1	P		
Parapsyche	12	P		
Rhyacophila	2			
Pupae (unidentified)	6	P		
Coleoptera (beetles)				
Elmidae	21			P
Adults (unidentified)	4		1	
Hemiptera (bugs)				
Corixidae	1			P
Isopoda (aquatic sow bugs)				
Asellus		P		P
Gastropoda (snails)				
Lymnaeidae	1			
Hydracarina (water mites)				
unidentified	7			
Diptera (flies)				
Chironomidae	18	P	1150	P
Rhagionidae	11			
Simuliidae	29	P	2450	P
Tipulidae		P		
Pupae (unidentified)			30	P
Hirudinea (leeches)				
unidentified			1	
Oligochaeta (worms)				
unidentified	2		45	P
Total Taxa/Station	18	11	8	6
Total Number of Organisms/Station	288	--	3680	--

and caddisflies. In addition, the total number of organisms increased considerably downstream (288 to 3680) mainly due to an increase of Chironomidae (midge) and Simuliidae (black flies). Both of these organisms would be thriving on increased quantities of organic matter. The increase in organisms was approximately tenfold and constitutes an undesirable imbalance in the community structure.

2. Aberfoyle Fisheries

Station locations and the basic operational layout of Aberfoyle Fisheries are illustrated in Figure 3. Water is pumped into the operation from two wells at an approximate rate of 5000 liters per minute. The water then passes through a number of indoor troughs after which the majority is diverted outside to the more westerly of the two settling ponds. The remaining portion of flow from the building passes through an indoor settling tank prior to being recycled through the outdoor raceways. Flow-through water from the outdoor raceways is also diverted to the west settling pond. Wastes accumulated during periods of clean-out flow to the east settling pond and the supernatant flows through a culvert to the west pond. Located in the west settling pond are two discharge points, one leading to the gravel pit operation and the other leading to Aberfoyle Creek. During the week, when the gravel pit is operating, 90% of the surface wastewater is used as wash water while the remaining 10% flows to Aberfoyle Creek. When the pit is not operating, all wastewater flows into the creek.

The upstream station was located immediately downstream from the confluence of two tributaries of Aberfoyle Creek. The site in general was observed to have a gravelly substrate with marginal growths of Cladophora and moss. The downstream site, located approximately 50 meters downstream from the discharge ditch, was situated in a dense woodlot area which greatly reduced the penetration of sunlight. The creek bed consisted of gravel and cobble which was lightly covered with silt. The immediate sampling

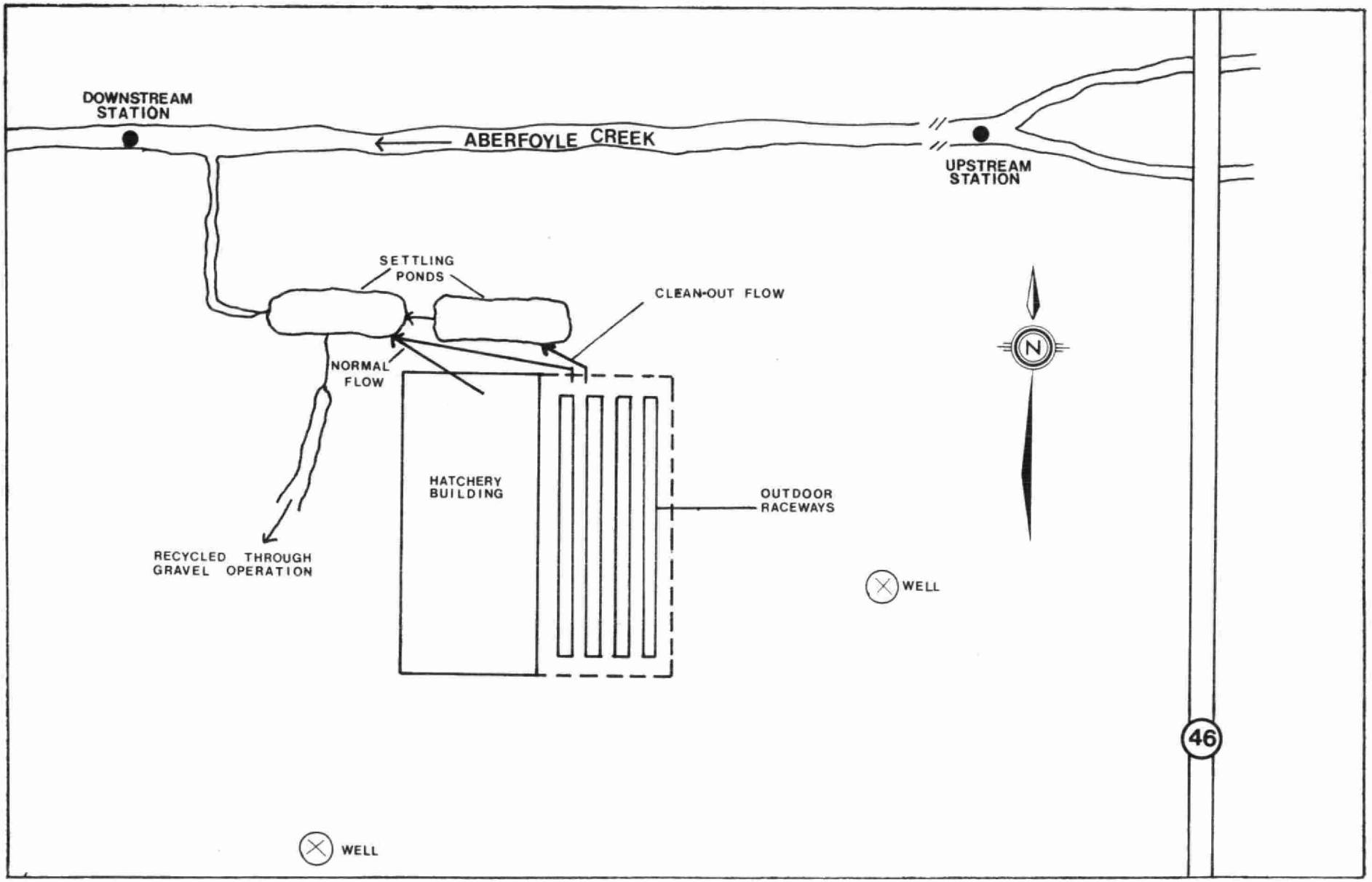

Figure 3: Station locations and operational layout for Aberfoyle Fisheries.

area had sparse growths of water cress and Cladophora; however, areas farther downstream where the forest canopy opened up to allow in the sunlight were heavily covered with long strands of Cladophora (up to 2 meters in length) and dense growths of water cress.

Results from macroinvertebrate sampling (Table 3) indicated relatively comparable findings in total taxa both downstream and upstream. The total numbers of organisms increased only slightly from 356 upstream to 522 downstream owing to an increase in the number of Chironomidae (midge).

3. Blue Springs Trout Farm

Station locations and the basic operational layout of the Blue Springs Trout Farm are illustrated in Figure 4. This operation can best be described as a two-phase system. The first or older section receives fresh spring water (at approximately 8000 liters per minute), where it is diverted through a number of raceways and then treated in a large sand filter. Effluent from the sand filter is then pumped into the second phase of the operation. Effluent produced from backwashing the sand filters is discharged to a ditch which carries the wastewater to a swampy area.

The second phase of the operation consists of a number of rearing ponds. Each pond has a bottom clean-out valve to remove heavier organic matter that has settled. Waste effluent from cleanout periods is discharged to a sludge pond. Wastewater from the normal flow through operation is discharged to a large settling pond which discharges to the Beatty Saugeen River.

The upstream sampling area was characterized by a clean gravelly substrate with limited algal growth. Two Surber samples were collected owing to the stream width (11.0 meters). Substrate downstream was similar to that

Table 3. Macroinvertebrates collected from Aberfoyle Creek in the immediate vicinity of the Aberfoyle Fisheries, August 13, 1981.

Organism	Upstream		Downstream	
	Surber	Qual.	Surber	Qual
Megaloptera				
Chauliodes (fishflies)			7	
Sialis (alderflies)				P
Ephemeroptera (mayflies)				
Baetis	19	P	60	
Caenis	25	P	1	
Hexagenia limbata				P
Paraleptophlebia		P	1	P
Stenonema	16	P	61	P
Trichoptera (caddis flies)				
Cheumatopsyche	28		36	
Chimarra		P		
Helicopsyche	115	P	125	P
Hydropsyche	3		3	
Psychomyia			1	
Pycnopsyche	6	P	1	P
Nectopsyche		P		
Neophylax	2			
Pupae (unidentified)	30	P	12	P
Odonata				
Agriidae (damselflies)		P		
Coleoptera (beetles)				
Elmidae	13	P	7	
Adults (unidentified)	32	P	4	
Amphipoda (scuds)				
Hyalella azteca		P	2	
Decapoda (crayfish)				
unidentified	1	P		
Pelecypoda (clams)				
Sphaeriidae	24	P	14	P
Gastropoda (snails)				
Lymnaeidae				P
Diptera (flies)				
Chironomidae	35	P	172	P
Sciomyzidae				P
Simuliidae	2			
Tipulidae	1		6	
Pupae (unidentified)	1		9	
Hirudinea (leeches)				
unidentified	1	P		
Oligochaeta (worms)				
unidentified	2			
Total Taxa/Station	16	15	15	10
Total Number or Organisms/Station	356	--	522	--

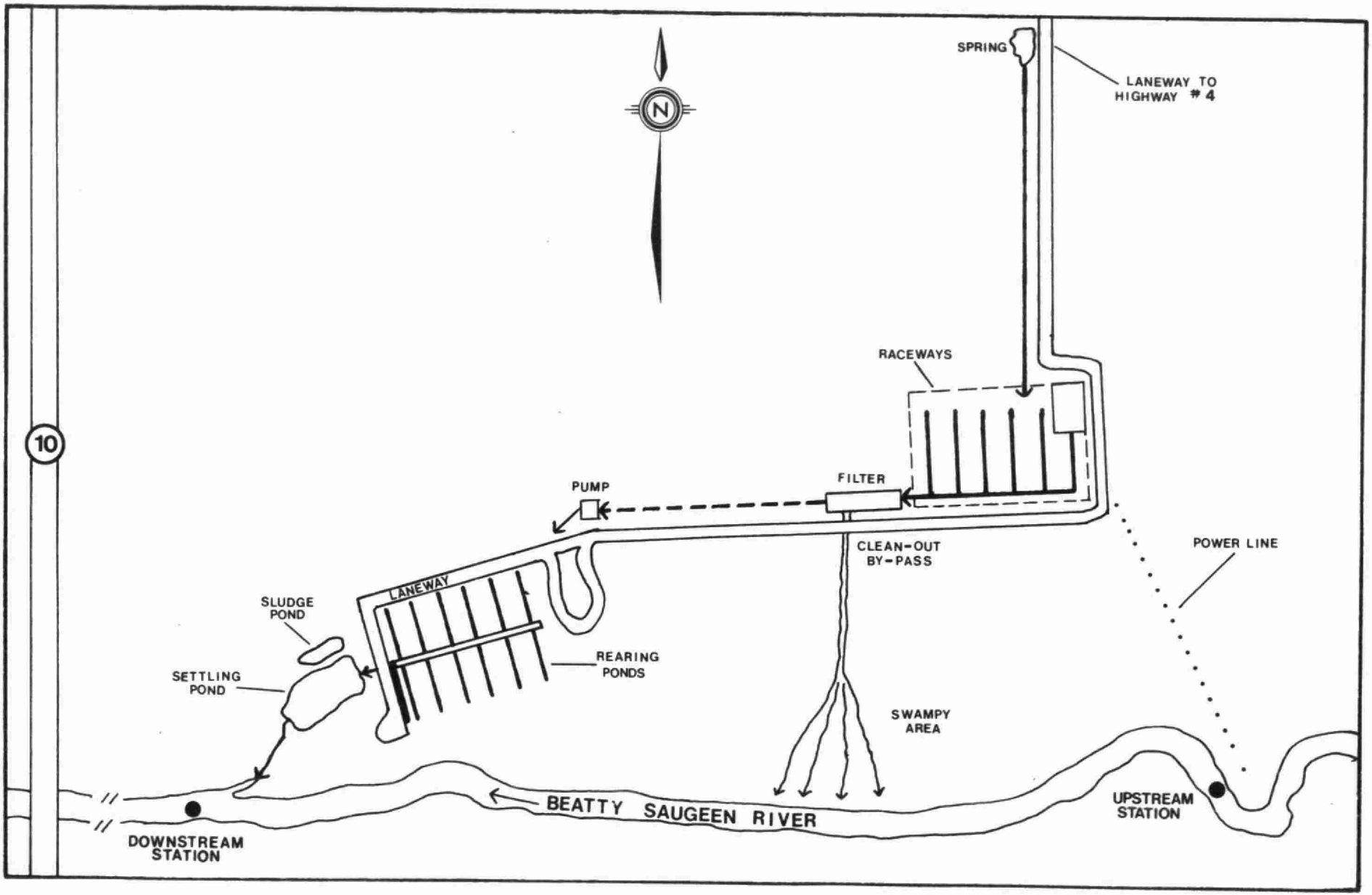

Figure 4: Station locations and operational layout for the Blue Springs Trout Farm.

observed upstream with the exception of some silting. The downstream macroinvertebrate sampling station was observed to be 20% covered by Cladophora and moss growths. However, the area of stream between the discharge and the sampling site was more noticeably affected as indicated by heavy silting and luxuriant growths of Cladophora. In addition, due to severe stream bank erosion, the discharge culvert had collapsed and was lying in the river.

Results from macroinvertebrate sampling (Table 4) indicated minimal change in total taxa downstream as compared to upstream. An increase in the number of Chironomidae downstream was responsible for an increase in the average total numbers of organisms (127 to 339). Numerous Chironomidae and Simuliidae were also observed in the organic deposits immediately below the outfall structure.

4. Springhills Trout Farm

Station locations and the basic operational layout of the Springhills Trout Farm are illustrated in Figure 5. Water is supplied to the operation, at an approximate rate of 2500 liters per minute, from a number of springs located to the east. After the spring water is collected, it is pumped through the operation which consists of a large number of raceways. The effluent from the raceways then passes through a small concrete settling basin (which provides very minimal retention) after which the effluent is discharged to a ditch forming one of the headwater tributaries of the Bighead River. Wastes from clean-out operations are diverted into an earthen settling pond for permanent retention.

In the Bighead River, sites upstream and downstream of the confluence of the tributary were both

Table 4. Macroinvertebrates collected from the Beatty Saugeen River in the immediate vicinity of the Blue Springs Trout Farm, August 12, 1981

Organism	Upstream			Downstream		
	Surber 1	Surber 2	Qual.	Surber 1	Surber 2	Qual.
Megaloptera						
Chauliodes (fishflies)			P			
Plecoptera (stoneflies)						
Acroneuria	2	4	P		2	P
Pteronarcella						P
Ephemeroptera (mayflies)						
Baetis	25	6		2	11	
Caenis					16	P
Hexagenia limbata	9	9		11	24	
Isonychia		2				P
Stenonema	1	13	P	2	22	P
Trichoptera (caddis flies)						
Cheumatopsyche	10	20	P	30	11	
Chimarra	3	1	P			
Hydropsyche	7	16	P	70	24	
Pupae (unidentified)		7			1	
Odonata						
Gomphidae (dragonflies)	1					
Coleoptera (beetles)						
Elmidae	26	1		2	15	
Psephenidae		3			1	
Adults (unidentified)	12	11		1	10	
Gastropoda (snails)						
Physidae						P
Hydracarina (water mites)						
unidentified	40			3		P
Diptera (flies)						
Chironomidae	16	1	P	168	194	P
Simuliidae		1			8	
Tipulidae	1			19	26	
Pupae (unidentified)	1			1	4	
Hirudinea (leeches)						
unidentified						P
Oligochaeta (worms)						
unidentified	2	3				
Total Taxa/Station	13	13	7	9	12	9
Total Number of Organisms/Station	156	98	--	309	369	--

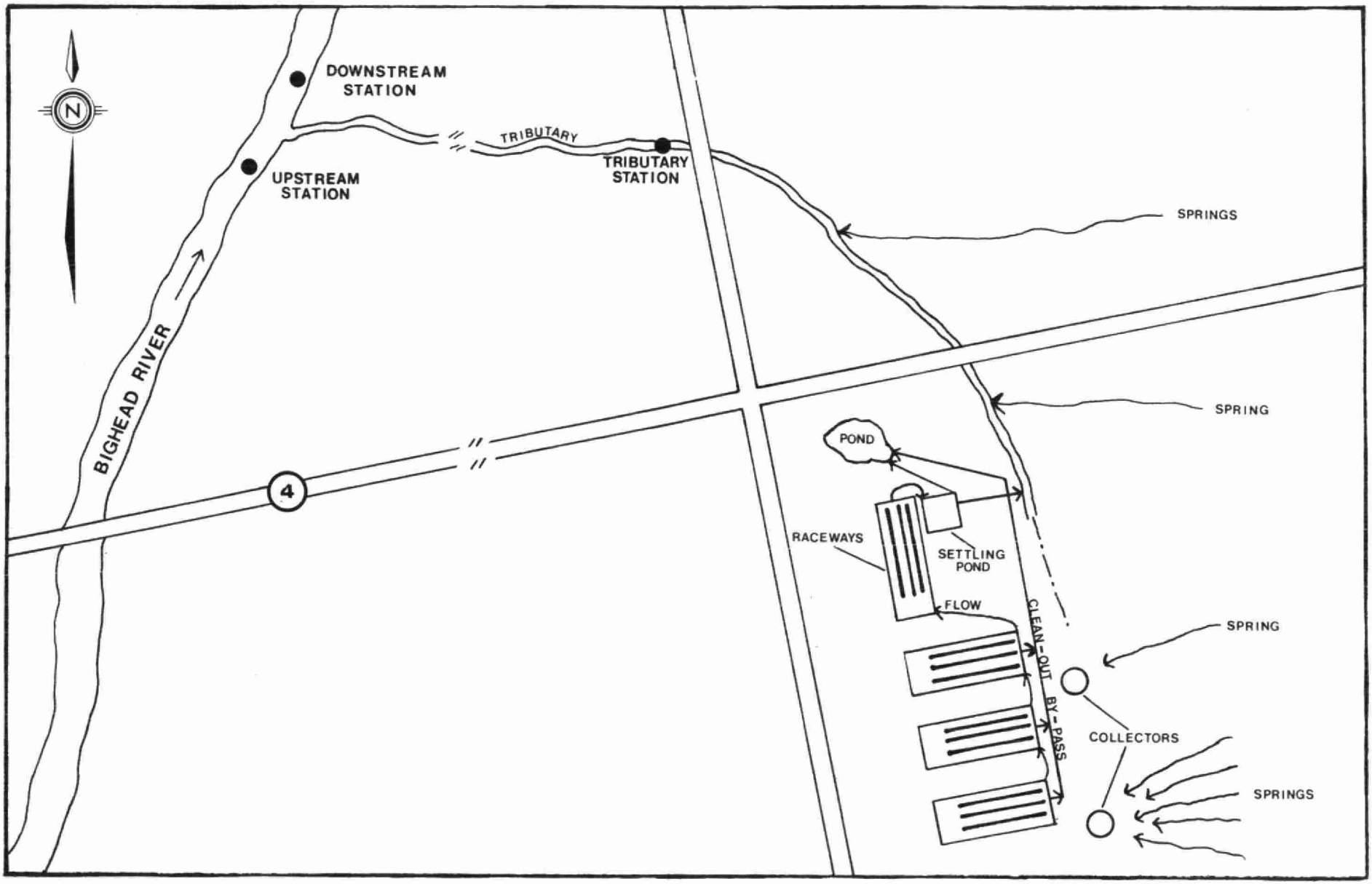

Figure 5: Station locations and operational layout for the Springhills Trout Farm.

characterized by clean gravelly substrate with limited plant growth. Owing to the long distance between the trout farm and the main Bighead River, a third sampling site was selected on the tributary stream to document any immediate effects of the effluent. Conditions at this site were observed as being very enriched as indicated by numerous areas of organic deposits and patches of Cladophora (ranging in lengths from 10 cm to 1 meter).

Macroinvertebrate sampling (Table 5) also indicated that the tributary was organically enriched as reflected by the total number of organisms (2335) present, which for the most part consisted of Simuliidae (1704). In the main Bighead River the total number of organisms rose from 102 upstream to 535 downstream. Although the increase in numbers of organisms is indicative of enrichment, total taxa were similar at the downstream station as well as the tributary station.

5. Aquafarm Canada Limited

The station locations and the basic operational layout are illustrated in Figure 6. The water supply for the operation is obtained from two sources. Approximately 5,500 liters per minute are drawn from the Beaver River and approximately 2,250 liters per minute come from a number of wells. Water from both sources is pumped into a mixing pond after which it is diverted through a number of outdoor ponds. The normal flow-through effluent is discharged directly to the Beaver River while clean-out effluent is treated in a large settling tank.

Upstream sampling was conducted at two locations, Station A and Station B. Station A was located in a swampy bog-type area which permitted only qualitative sampling. Station B was located in a gravelly area where both

Table 5. Macroinvertebrates collected from a tributary and the Bighead River in the immediate vicinity of the Springhills Trout Farm, August 11, 1981.

Organism	Discharge Tributary		Upstream		Downstream	
	Surber	Qual.	Surber	Qual.	Surber	Qual.
Plecoptera (stoneflies)						
Alloperla				P		
Isocapnia	4	P	11	P	2	P
Ephemeroptera (mayflies)						
Baetis	67	P	14	P	74	P
Ephemerella					2	
Paraleptophlebia			3	P		
Trichoptera (caddis flies)						
Cheumatopsyche				P		
Dolophilodes						P
Hesperophylax		P				
Hydropsyche			11	P	35	P
Lepidostoma				P		
Oligostomis				P		P
Parapsyche	7	P			4	
Rhyacophila	7				16	P
Pupae (unidentified)					5	P
Coleoptera (beetles)						
Elmidae	42		2	P	11	
Adults (unidentified)				P	6	P
Gastropoda (snails)						
Lymnaeidae	1					
Physidae				P		P
Pelecypoda (clams)						
Sphaeriidae				P		P
Hydracarina (water mites)						
unidentified	20			P	10	
Diptera (flies)						
Chironomidae	447	P	15	P	120	P
Ephydridae					4	
Rhagionidae	20	P				
Simuliidae	1704	P	44	P	243	P
Tabanidae						P
Tipulidae	1		2			P
Pupae (unidentified)	2	P		P	2	
Hirudinea (leeches)						
unidentified		P				
Oligochaeta (worms)						
unidentified	13				1	
Total Taxa/Station	12	8	8	14	12	13
Total Number of Organisms/Station	2335	--	102	--	535	--

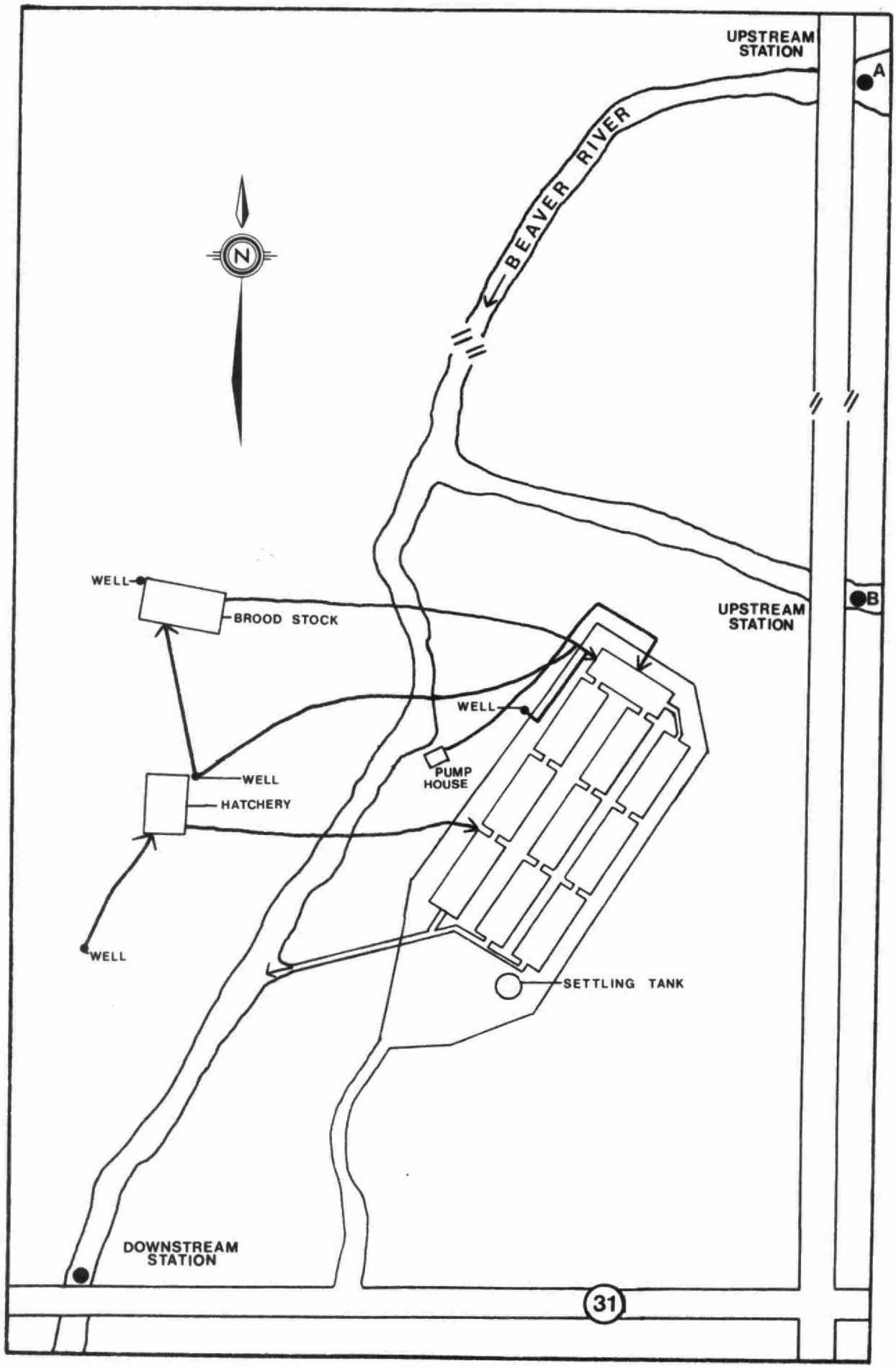

Figure 6: Station locations and operational layout for Aquafarm Canada Limited.

qualitative and quantitative samples were collected. Both areas were noted as having clean substrate with little plant growth present.

The downstream station was observed to have luxuriant growths (70% coverage) of water cress. This increase in aquatic plant growth continued for a considerable distance downstream. In addition, large areas of organic build-up on the river bottom were noted immediately below the outfall.

Results from macroinvertebrate collections (Table 6) indicated a slight increase in the total numbers of organisms (154 to 325). Total taxa for all stations remained relatively consistent.

Water Analysis

Results from water sample analyses are presented in Table 7. Total phosphorus increased downstream from all operations. Three of the five operations had downstream concentrations of total phosphorus which exceeded the Ministry of the Environment Water Management objective of 0.03 mg/l for protection against excessive plant growth in rivers and streams. The Spring Valley Trout Farm showed the highest increase in total phosphorus (0.052 to 0.166). In addition, the downstream concentration of ammonia (0.026 mg/l as NH_3) was slightly in excess of our objective (0.02 mg/l as NH_3) for the protection of aquatic life.

Table 6. Macroinvertebrates collected from the Beaver River in the immediate vicinity of Aquafarm Canada Limited, July 27, 1981.

Organism	Upstream A Qual.	Upstream A Qual.	Upstream B Surber	Upstream B Surber	Upstream B Qual.	Downstream Surber	Downstream Surber	Downstream Qual.
Megaloptera								
Sialis (alderflies)	P	P	1					
Plecoptera (stoneflies)								
Acroneuria			4	2		1		
Isocapnia			5	1	P	6	8	
Ephemeroptera (mayflies)								
Baetis	P		11	17	P	26	80	P
Dannella			2	2				
Paraleptophlebia				3		2		
Stenonema				2	P			
Tricorythodes			3	10	P	35	5	P
Trichoptera (caddis flies)								
Cheumatopsyche			1					
Glossosoma							2	
Helicopsyche				1				
Hydropsyche			12	9	P		101	P
Lepidostoma	P	P	1			15	1	P
Polycentropus			2	2				
Psychomyia			3					
Pycnopsyche			8	4		2	2	
Pupae (unidentified)						5	2	P
Odonata								
Gomphidae (dragonflies)	P							
Coleoptera (beetles)								
Elmidae			14	2	P	3	1	
Adults (unidentified)	P		6	3	P	2	2	
Hemiptera (bugs)								
Corixidae	P	P			P			
Isopoda (aquatic sow bugs)								
Asellus				1				
Amphipoda (scuds)								
Gammarus	P	P	2			72	10	P
Hyalella azteca	P	P		4	P			
Pelecypoda (clams)								
Sphaeriidae		P			P	1	1	P
Gastropoda (snails)								
Physidae	P	P	1		P	19	14	P
Hydracarina (water mites)								
unidentified	P	P	15	17	P	10	18	

Table 6. (continued)

Organism	Upstream A Qual.	Upstream A Qual.	Upstream B Surber	Upstream B Surber	Upstream B Qual.	Downstream Surber	Downstream Surber	Downstream Qual
Diptera (flies)								
Chironomidae	P	P	80	54		56	106	P
Rhagionidae						10		
Tabanidae	P			1				
Pupae (unidentified)				1		7	3	
Hirudinea (leeches) unidentified						1		P
Oligochaeta (worms) unidentified	P	P	1			14	6	
Total Taxa/Station	13	10	18	17	11	16	14	9
Total Numbers of Organisms/Station	--	--	172	136	--	287	362	--

Table 7. Results of water sample analyses for nitrogen and phosphorus.

Location	Nitrogen (mg/l)				Phosphorus (mg/l)	
	Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total Phosphorus	Soluble Phosphorus
1. Spring Valley Trout Farm						
upstream	.018	1.55	.013	21.0	.052	.001
downstream	.6	1.22	.002	11.5	.166	.042
2. Aberfoyle Fisheries						
upstream	.022	.65	.002	.015	.032	.001
downstream	.014	.62	.003	.020	.048	.001
3. Blue Springs Trout Farm						
upstream	.014	.28	.006	.865	.008	.001
downstream	.062	.34	.009	.760	.012	.001
4. Springhills Trout Farm						
upstream	.012	.14	.005	2.850	.005	.002
downstream	.012	.64	.007	1.940	.039	.021
5. Aquafarm Canada Limited						
upstream	.025	.49	.003	1.06	.018	.006
downstream	.020	.45	.006	1.0	.019	.011

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WARREN, C.E., 1971. Biology and Water Pollution Control. W. B. Saunders Co., Toronto.